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Yakovenchukite-(Y), $K_3NaCaY_2(Si_{12}O_{30})(H_2O)_4$, a new mineral from the Khibiny massif, Kola Peninsula, Russia: A novel type of octahedral-tetrahedral open-framework structure

Sergey V. Krivovichev,[1,*] Yakov A. Pakhomovsky,[2] Gregory Yu. Ivanyuk,[2] Julia A. Mikhailova,[2] Yuri P. Men'shikov,[2] Thomas Armbruster,[3] Ekaterina A. Selivanova,[2] and Nicolas Meisser[4]

[1]St. Petersburg State University, Department of Crystallography, University Emb. 7/9, 199034 St. Petersburg, Russia
[2]Geological Institute of the Kola Science Center of the Russian Academy of Sciences, 14 Fersman Str., Apatity 184200, Murmansk Region, Russia
[3]Laboratorium für chemische und mineralogische Kristallographie, Universität Bern, Freiestrasse 3, CH-3102 Bern, Switzerland
[4]Musée Géologique Cantonal & Laboratoire des Rayons-X, Institut de Minéralogie, UNIL-BFSH2, CH-1015 Lausanne-Dorigny, Switzerland

Abstract

Yakovenchukite-(Y), $K_3NaCaY_2[Si_{12}O_{30}](H_2O)_4$, is a new REE silicate found in a thin (3–4 cm) sodalite-aegirine-microcline veinlet cutting ijolite-urtite at Mt. Kukisvumchorr, Khibiny alkaline massif, Kola Peninsula, Russia. The mineral occurs as small prismatic crystals in intimate association with microcline, aegirine, calcite, catapleiite, donnayite-(Y), fluorapophyllite, fluorite, galena, lead, litharge, molybdenite, natrolite–gonnardite, pyrochlore, rinkite, strontianite, and vuorijarvite-K. Yakovenchukite-(Y) is creamy to colorless, with vitreous luster. The streak is white. The mineral is transparent, non-fluorescent. The Mohs hardness is about 5. The mineral is brittle. Cleavage is perfect on {100}, distinct on {010}, fracture is stepped. Densities are 2.83 g/cm^3 (measured by sink/float in heavy liquids) and 2.72 g/cm^3 (calculated). Yakovenchukite-(Y) is biaxial (+): n_α = 1.520(5), n_β = 1.525(5), n_γ = 1.538(5) (589 nm), $2V$(meas.) = 60 ± 5°, $2V$(calc.) = 61.86°. The optical orientation is Y = **c**, X = **a**, Z = **b**, pleochroism is not observed. Chemical analysis by electron microprobe (wt%): Na_2O 4.32, K_2O 10.73, CaO 3.42, Y_2O_3 15.49, Ce_2O_3 0.10, Dy_2O_3 0.68, Er_2O_3 0.88, Tm_2O_3 0.18, Yb_2O_3 1.53, ThO_2 0.62, SiO_2 57.55, H_2O (by the Penfield method) 4.70, total 100.20. The empirical formula (based on Si = 12 apfu) is $(K_{2.85}Na_{0.15})_{\Sigma 3.00}Na_{1.00}(Ca_{0.71}Na_{0.60})_{\Sigma 1.31}(Y_{1.72}Yb_{0.10}Er_{0.06}Dy_{0.05}Th_{0.03}Ce_{0.01}Tm_{0.01}Ca_{0.05})_{\Sigma 2.03}[Si_{12}O_{30.02}]\cdot 3.27H_2O$. According to single-crystal X-ray study yakovenchukite-(Y) is orthorhombic, *Pcca*, a = 14.972(8), b = 14.137(7), c = 14.594(8) Å, V = 3089(3) Å^3, Z = 4. The strongest lines of the X-ray powder diffraction pattern are [d_{bs}(Å) (I_{obs}) (*hkl*)]: 7.00 (40) (020), 6.57 (60) (102), 4.20 (50) (222), 3.337 (100) (331), 3.248 (90) (024), 3.101 (40) (142), 3.014 (80) (422), 2.608 (40) (404). The crystal structure of yakovenchukite-(Y) belongs to a new structure type of minerals and inorganic compounds. It is based on microporous octahedral-tetrahedral framework of SiO_4-tetrahedra and YO_6-octahedra. Silicate tetrahedra share corners to form unprecedented $[Si_{12}O_{30}]$ sheets consisting of 4-, 6-, and 14-membered rings. The sheets are parallel to (001) and are linked into 3D framework through YO_6 octahedra. Ca^{2+}, K^+, and Na^+ cations are located within the framework cavities. The octahedral-tetrahedral framework possess channels extended along the **a** axis. The channel dimensions are 4.9 × 6.2 Å, which means the free crystallographic diameter of 2.2 × 3.5 Å, that allows classifying yakovenchukite-(Y) as a microporous material. Yakovenchukite-(Y) is the latest low-temperature hydrothermal mineral, formed by alteration of earlier REE-rich minerals (pyrochlore, rinkite, etc.). The mineral is named in honor of Victor N. Yakovenchuk, a mineralogist at the Geological Institute of the Kola Science Centre of the Russian Academy of Sciences, for his outstanding contribution to the mineralogy of alkaline and alkaline-ultrabasic massifs.

Keywords: Yakovenchukite-(Y), new mineral, REE-silicate, crystal structure, ultra-alkaline hydrothermal vein, Khibiny massif, Kola Peninsula